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INNOVATIONS IN ACNE THERAPY: A COMPARATIVE REVIEW OF RADIOFREQUENCY AND NEEDLING FOR CLOSED COMEDONES

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Abstract

Acne vulgaris remains one of the most prevalent dermatological conditions globally, profoundly affecting the quality of life of individuals across diverse age groups. Closed comedones, or whiteheads, represent an early, non-inflammatory lesion in acne pathogenesis that often progresses to inflammatory papules or pustules if left untreated. Contemporary therapeutic approaches are evolving beyond conventional pharmacological interventions, with minimally invasive technologies such as radiofrequency (RF) therapy and microneedling emerging as promising modalities. This review delineates the mechanistic principles, efficacy profiles, and safety considerations of RF and needling therapies, drawing from contemporary literature to evaluate their roles in the management of closed comedones.

Keywords: Acne vulgaris, Closed comedones, Radiofrequency therapy, Microneedling, Minimally invasive dermatology, Skin rejuvenation, Sebaceous gland modulation

INTRODUCTION

Acne vulgaris is a chronic inflammatory disease of the pilosebaceous unit, characterized by a multifactorial etiology involving increased sebum production, follicular hyperkeratinization, microbial colonization (notably by *Cutibacterium acnes*), and inflammation. Closed comedones are one of the earliest clinical signs of acne, resulting from the accumulation of keratin and sebum within the follicular infundibulum without follicular rupture or exposure to air (Thiboutot et al. 2009). Although non-inflammatory, closed comedones contribute to acne progression and scarring if inadequately treated.

Traditional treatments, including topical retinoids, benzoyl peroxide, and systemic antibiotics, offer limited efficacy in comedonal acne and are often associated with adverse effects such as irritation, microbial resistance, and recurrence (Zaenglein et al. 2016, Du Crest et al. 2024). The increasing demand for non-pharmacological, minimally invasive procedures has brought attention to RF-based modalities and microneedling as viable alternatives or adjuncts. These innovations offer targeted dermal remodeling, sebaceous gland modulation, and enhanced drug delivery, showing potential in comedonal resolution.

Pathophysiology of Closed Comedones

Closed comedones arise due to the hyperproliferation and impaired desquamation of keratinocytes within the follicular epithelium, leading to the obstruction of the follicular orifice. Sebum accumulation and retention within

the follicle result in distension without oxidation, hence the white appearance. Closed comedones may evolve into inflammatory lesions if this milieu favors *C.acnes* colonization and inflammation ensues (Cavallo et al. 2022). Effective management requires interventions that target follicular keratinization, normalize sebum output, and prevent progression to inflammation, objectives well-aligned with the mechanisms of Radiofrequency Therapyand Microneedling therapies (Fig1).

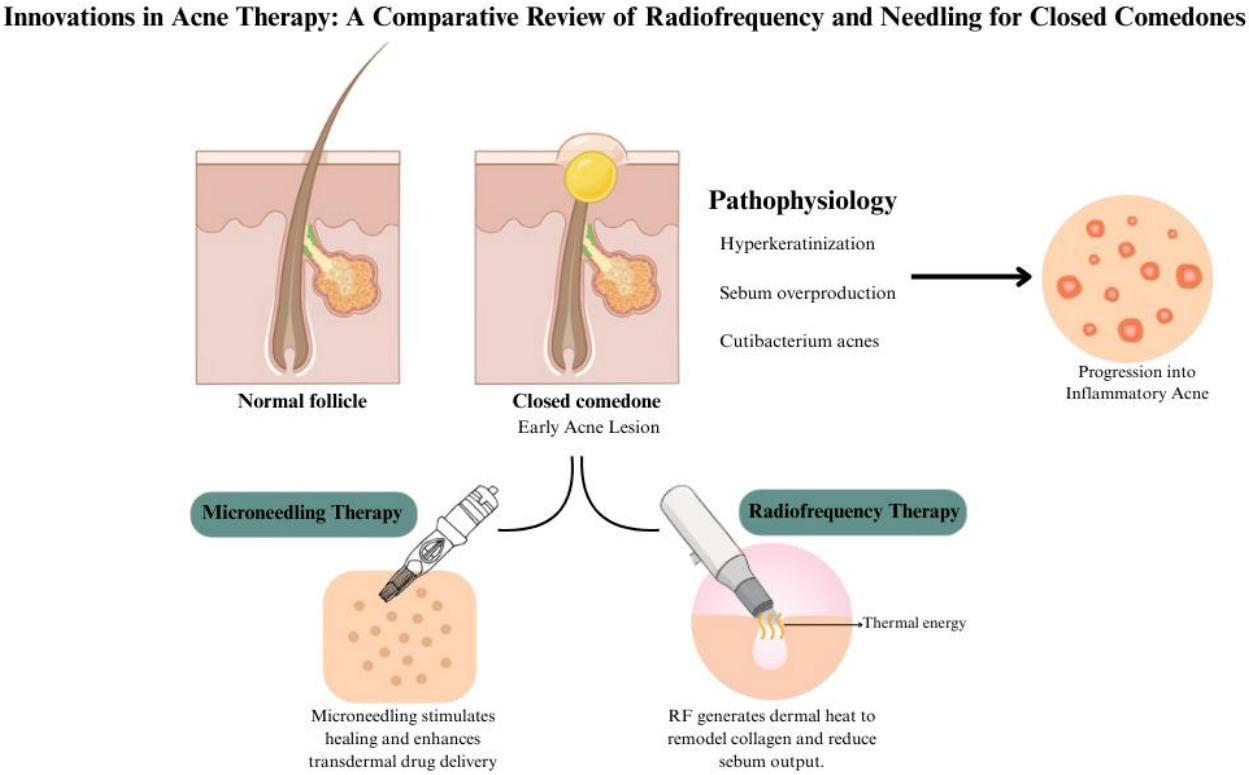

Fig 1: This diagram illustrates the development of closed comedones and compares the therapeutic mechanisms of microneedling and radiofrequency (RF) therapy. It shows the transition from a normal follicle to a closed comedone, followed by potential progression into inflammatory acne. The lower section highlights how microneedling stimulates healing and enhances transdermal drug delivery, while RF therapy delivers thermal energy to remodel collagen and reduce sebum output, both offering effective, minimally invasive treatment options.

1. RADIOFREQUENCY THERAPY

Mechanism of Action

Radiofrequency (RF) therapy utilizes high-frequency electromagnetic waves to generate thermal energy in the dermis while sparing the epidermis. This thermal stimulation induces collagen remodeling, dermal tightening, and sebaceous gland thermolysis. RF energy can be delivered via monopolar, bipolar, or multipolar devices, with fractional microneedling RF (MNRF) combining thermal and mechanical effects.

Clinical Evidence

A randomized controlled trial by Kim et al. (Kim et al. 2014, Singh H et al. 2025) demonstrated a significant reduction in comedonal lesions following fractional RF therapy, with sustained improvement after 12 weeks. Moreover, MNRF has shown superiority in treating acne scars and active acne simultaneously due to its dual-action mechanism. RF therapy has also been reported to downregulate sebum production by damaging sebaceous glands, thereby reducing comedone formation.

Safety and Adverse Effects

RF therapy is generally well-tolerated, with transient erythema and mild edema being the most common side effects. Complications such as burns or post-inflammatory hyperpigmentation are rare, particularly with fractional systems that allow for greater control of thermal diffusion.

2. MICRONEEDLING THERAPY

Mechanism of Action

Microneedling, or percutaneous collagen induction therapy, involves the use of fine needles to create controlled micro-injuries in the skin. These microchannels stimulate dermal fibroblast activity and initiate a wound healing cascade, resulting in neocollagenesis and neovascularization. Additionally, the microchannels facilitate the enhanced transdermal delivery of topicals, including retinoids or growth factors, making it a synergistic tool for acne management.

Clinical Evidence

Several studies have demonstrated the efficacy of microneedling in treating acne-related lesions. Dogra et al. (Dogra, Yadav, and Sarangal 2014) reported marked improvement in closed comedones and early inflammatory lesions following microneedling, particularly when combined with topical retinoids. Furthermore, needling improves epidermal turnover and keratinocyte desquamation, addressing the core pathogenic factor in comedogenesis.

Safety and Tolerability

Microneedling is minimally invasive with a favorable safety profile. Common adverse effects include transient erythema, edema, and pinpoint bleeding. When aseptic precautions are maintained, the risk of infection or scarring is minimal.

Both modalities offer unique advantages. RF therapy exerts a deeper and more thermally driven remodeling effect, making it ideal for recalcitrant lesions and sebaceous gland modulation. Microneedling, meanwhile, offers superior safety and versatility, particularly in combination with pharmacologic agents.

Future Directions and Integration into Clinical Practice

Emerging innovations involve the integration of both RF and microneedling into single devices, enabling simultaneous mechanical and thermal stimulation, enhancing efficacy while reducing treatment sessions. Further exploration into personalized parameters, such as lesion morphology and skin phototype, can improve therapeutic outcomes.Incorporating these modalities into a multimodal acne treatment protocol—alongside chemical peels, photodynamic therapy, or topicals may yield synergistic benefits, especially in patients unresponsive to conventional therapies.

CONCLUSION

The management of closed comedones necessitates approaches that address follicular keratinization and sebum dysregulation. RF and microneedling therapies provide innovative, non-invasive strategies with substantial efficacy and favorable safety profiles. RF offers deep dermal remodeling with sebaceous gland attenuation, while microneedling enhances epidermal turnover and transdermal delivery. Their integration into clinical practice represents a significant advancement in personalized acne care, with ongoing research poised to optimize their application further.

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